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NOTES ON STRIPPING MACHINERY MASS ESTIMATES

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NOTES ON STRIPPING MACHINERY MASS ESTIMATES

by

V.Srajer*, M.Heximer**, W.Veldhuis**

ABSTRACT

This report concludes part of a project dealing with definitions of movement of loading and stripping systems at western Canadian coal mines. In general, the study concentrated on searching for procedures to appraise deeper stripping problems. It was found, that a rapid method is desirable to make a preliminary evaluations of potential strip mining operations. The trends in the relationship of the weight of the machine to its ability to do stripping work is investigated. A program was written to provide a simple overcasting analysis.

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NOTES SUR LES ÉVALUATIONS EN SÉRIE D'UN EXCAVATEUR

par

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RÉSUMÉ

Le présent rapport est la conclusion d'une partie de projet ayant pour but de définir le mouvement des systèmes de chargement et d'excavation dans les mines de charbon de l'Ouest canadien. En général, la recherche de méthodes servant à évaluer les problèmes associés à l'excavation en profondeur a été au centre de l'étude. Il en est ressorti qu'il serait souhaitable d'avoir une méthode préliminaire rapide pour évaluer la possibilité de procéder à une exploitation par excavateurs. De plus, une étude de la relation entre le poids de la machine et sa capacité d'effectuer des travaux d'excavation a été réalisée. Enfin, on a écrit un programme dans le but de fournir une analyse sommaire de la question.

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INTRODUCTION

The only known practicable way to accurately evaluate a proposed stripping operation is to make detailed studies, step by step, including cost estimates. The introduction of computer systems into the mining operation may shorten this cumbersome procedure, but will not provide fast insight into the future of the operation. The presented report may provide an alternative to the estimating procedure, to analyse stripping process in relationship of the weight of the machine to its ability to do stripping work. In addition, the presented approach shows situations where the geometry of each cut-and-spoil section is assumed to take certain defined relationships for varying overburden depths. Slopes are considered to be stable, soil mechanics factors are neglected for simplicity.

A program in Vax Fortran, that utilizes the Calcomp plotter to produce graphs of maximum usefulness factors for shovel and dragline vs. overburden depth, was written and is presented in this report.

MAXIMUM USEFULNESS FACTOR CONCEPT

The Maximum Usefulness Factor (MUF) concept was introduced 25 years ago (1) to provide a relationship between the weight of the machine to its value as an excavator. The value has been arbitrarily established as the product of the nominal dipper size of the shovel or dragline multiplied by a functional dumping reach.

The MUF for shovels is defined as the product of the nominal dipper size [in m^3] times the dumping reach "r" [m]. The MUF is equal to the load moment at the point "T" of the base of the shovel in terms of [$m^3 * m$]. The shovel reach diagram is in Fig.1

FIG 1: SHOVEL

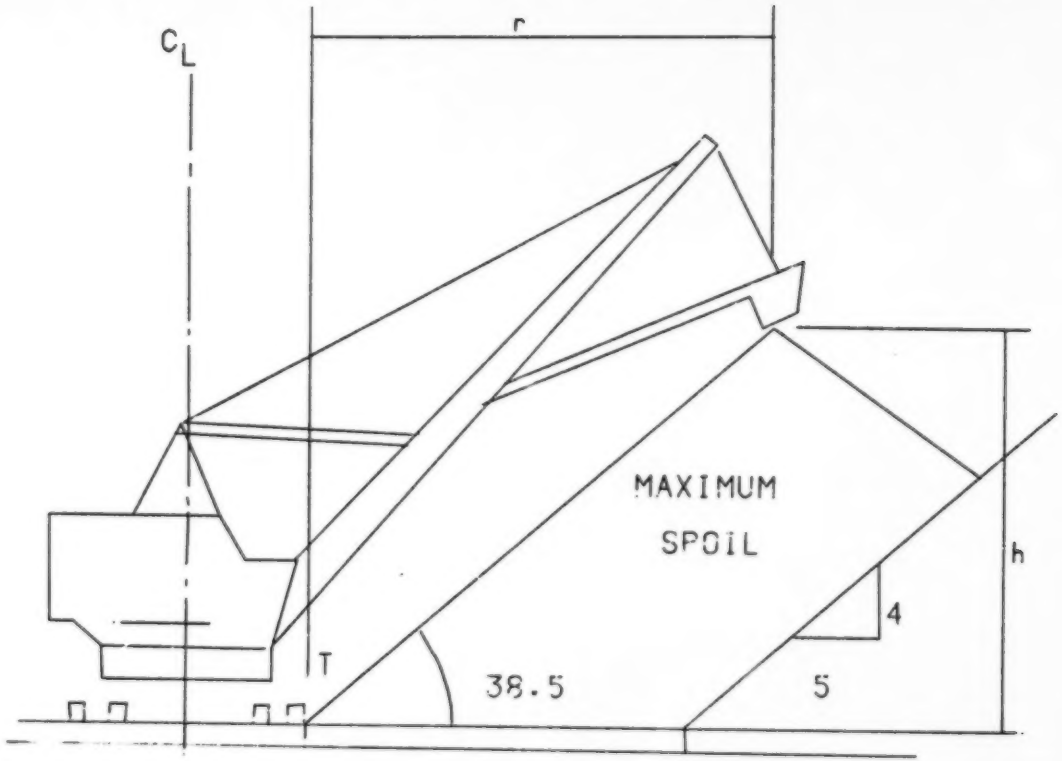


Fig. 1 - Shovel Reach Diagram Graph

The MUF calculation for draglines uses the dumping reach [r] as a controlling factor. The dragline normally works from the surface of a cut or from a bench slightly below the surrounding land surface, so the dumping height is not an influencing factor. The diameter of the tub is extended by a 1.5 m safety margin between the top edge of the old highwall and the closest point of the tub, and a moment centre "T" is established. Measuring from the "T" to the dumping point gives a moment arm "r" for each dragline considered. The nominal 2150 kg weight of the bucket was selected to represent the unit weight of the bucket plus its content. The specified suspended load of the machine is divided by this number to give the nominal [m^3] bucket capacity. This capacity multiplied by the value of "r" determines the MUF for each dragline. It is equal to the load moment about "T" in terms of [m^3* m]. The dragline reach diagram is in Fig. 2.

MUF IN PIT GEOMETRY

In addition to the relationships between the MUF and weight of the machine, it is necessary to determine the relationship between the geometry of the pit section and the MUF numbers for varying depths of overburden. These numbers will be related to projected machine gross weight which, in effect, establishes a relationship between stripping machinery mass and overburden volumes or depths.

The formulae to calculate the shovel reach "r" (1) is as follows:

$$r = (SLOPE) * [(1 + S/100) * H - t + W/5] \quad \ldots\ldots[1]$$

where

r...reach [m],
S...swell [%],

FIG 2: DRAGLINE

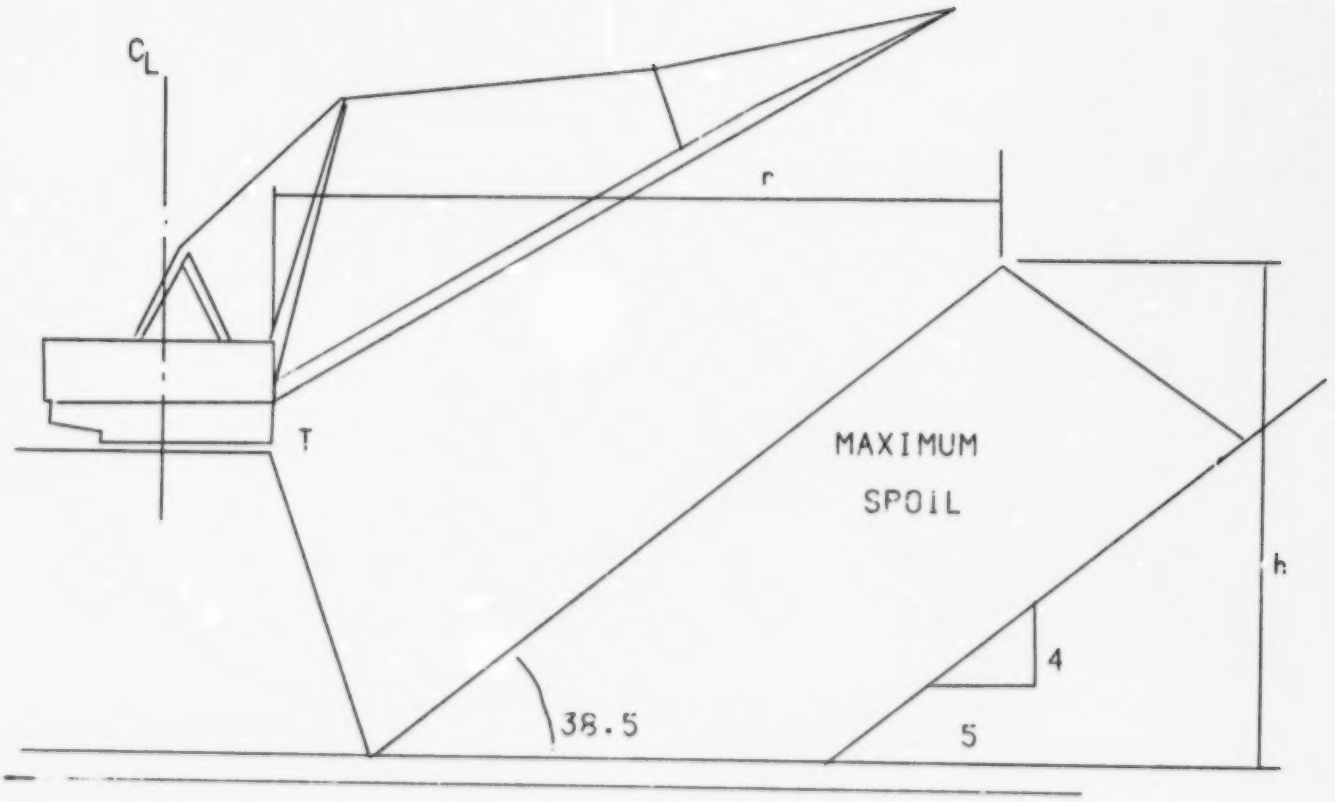


Fig.2 - Dragline Reach Diagram Graph

H...overburden depth [m],
W...cut width [m], and
t...deposit thickness [m].

The nominal shovel dipper size, the average digging cycle, the dipper load, and the monthly operating factor are all inpuit parameters. The required MUF for the shovel at any overburden depth [H] is then (1):

$$MUF = r * D \quad [2]$$

where

$$D = (Q_c * 10\,000 * H) / (L * \text{DIPPER FACTOR}) \quad [3]$$

and means

Q_c ...required net tonnes of cleaned coal per month,
H ....overburden depth [m], and
L ....net tonnes of cleaned coal yielded per hectare.

The dragline reach is calculated from the following formulae (1):

$$r = (0.33 * H - 0.33 * B) + \text{SLOPE} * [(1 + S/1000) * H - t + W/5] \quad [4]$$

where

r ....reach [m],
S ....swell [%],
H ....overburden depth [m],
W ....cut width [m],
t ....deposit thickness [m], and
B ....bench cut [m].

The MUF for the dragline will be (1):

$$MUF = r * B \quad \text{.....[5]}$$

where

$$B = (Q_c * 10\,000 * H) / (L * \text{BUCKET FACTOR}) \quad \text{.....[6]}$$

and means

Q_c ...net tonnes of cleaned coal per month,
H ....overburden depth [m], and
L ....yield per hectare of net tonnes of cleaned coal.

PROBLEM SOLVING BY COMPUTER ANALYSIS

The program is written in Fortran and utilizes Calcomp plotter to produce a graph comparing the MUF for shovel and dragline versus overburden depth. The program prompts for a number of input parameters, such as:

-a range of overburden depths,
-swell,
-deposit thickness,
-width of cuts,
-slope,
-dipper/bucket factor,
-cycle time,
-hours of operation,
-operating factor,
-height of bench cut,
-required production of clean coal, and

-yield/hectare.

All values calculated are listed in an output file. Table 1 is an example of the output file printout.

To run the program type "RUN PMM" <CR>. The prompt 'ENTER INPUT PARAMETERS FROM SCREEN (S) OR FILE (F)' will appear.

Type "S" if input is to come from the terminal, follow the prompt. Type "F" if input is to come from a file. You will then be asked for the name of the input file.

The prompt 'PLOT GRAPH (Y/N)?' will appear on the screen. Type "Y" if you are at the terminal connected to the Calcomp plotter and if you wish to produce the graph comparing MUF versus overburden depth for shovel and dragline. Otherwise type "N".

If "Y" was entered, the prompt appears 'POSITION THE PAPER ON PLOTTER THEN PRESS <RETURN>'. Position the plotter pen onto the bottom lefthand corner of the paper. The plotter is set-up by:

1. Turn on the plotter,
2. Press <ENTER> and wait for plotter to initialize,
3. Press <RELOCATE PLOT>,
4. Move pen to new position and press <ENTER>, and
5. Press <AUTO>, <ENTER>, <AUTO>.

The plotter is now ready to plot a graph. Press <RETURN> on the keyboard and wait for the graph to be drawn. The example of graphics output is enclosed in Fig. 3. The program listing is enclosed in Appendix.

PROPER MACHINERY MASS OUTPUT

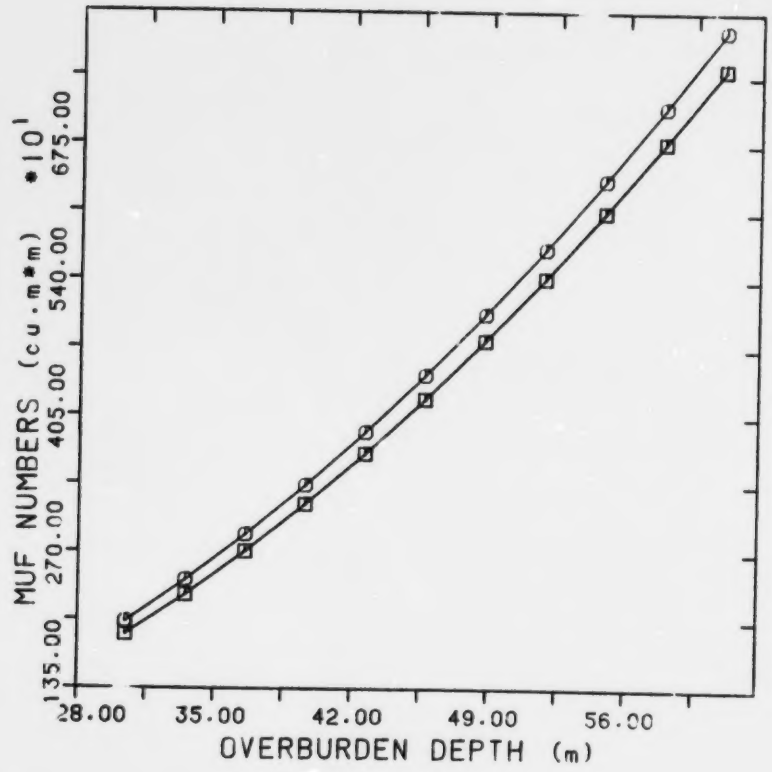
INPUT PARAMETERS

swell(%) = 25.00 deposit thickness(m) = 3.66
Tons of clean coal required per month = 1814.40
Yeild in net Tons of cleaned coal/Hectare = 448.34
Height of benchcut for dragline (m) = 3.05

	SHOVEL	DRAGLINE
Width of cut (m)	18.29	24.38
Dipper/Bucket factor	0.80	0.80
Cycle time (seconds)	56.00	58.00
Monthly operating hours	720.00	720.00
Monthly operating factor	0.85	0.85
Expected output/mth (cu.m)	31334.40D	30355.20B

	SHOVEL				DRAGLINE			
ovbrdn height	height of spoil	reach	dipper size	MUF	height of spoil	reach	dipper size	MUF
30.5	38.1	47.63	39.37	1874.8	39.3	58.20	40.64	2006.3
33.5	41.9	52.39	43.30	2268.5	43.1	63.97	44.70	2419.9
36.6	45.7	57.15	47.24	2699.7	46.9	69.74	48.76	2872.2
39.6	49.5	61.91	51.18	3168.4	50.7	75.51	52.83	3363.2
42.7	53.3	66.68	55.11	3674.6	54.6	81.27	56.89	3892.9
45.7	57.2	71.44	59.05	4218.3	58.4	87.04	60.95	4461.4
48.8	61.0	76.20	62.99	4799.5	62.2	92.81	65.02	5068.5
51.8	64.8	80.96	66.92	5418.2	66.0	98.58	69.08	5714.3
54.9	68.6	85.73	70.86	6074.4	69.8	104.35	73.14	6398.9
57.9	72.4	90.49	74.80	6768.0	73.6	110.12	77.21	7122.1
61.0	76.2	95.25	78.73	7499.2	77.4	115.88	81.27	7884.1

Table 1 - Example of Computer Printout.



MAXIMUM USEFULNESS FACTOR
VS
OVERBURDEN DEPTH

□ = SHOVEL

⏲ = DRAGLINE

INPUT PARAMETERS

Swell = 25.00
Bed Thickness = 3.66
Clean Tons/mth = 1814.40
Yield Tons/Hectare = 448.34
Height of Benchcut for Dragline = 3.05

	SHOVEL	DRAGLINE
Width of cut (m)	18.29	24.38
Dipper/Bucket factor	0.80	0.80
Cycle time (seconds)	56.00	58.00
Monthly operating hours	720.00	720.00
Monthly operating factor	0.85	0.85
Expected output/mth (cu.m)	31334.40D	30355.20B

Fig. 3 - Maximum Usefulness Factor Graph.

CONCLUSION

The aim of this report was to illustrate an approach for preliminary stripping analysis using the so called Maximum Usefulness Factor (MUF) of stripping shovels and draglines. The example provided in this report appears to be slightly unrealistic in order to focus attention on the approach and procedure in analysing such problems.

The report demonstrates that the procedure is quite simple but reliable in approximating the size of machines required for simple sidecasting at different overburden depths and other defined sets of conditions. These conditions may be selected arbitrarily, or they may be determined by experience in the particular property or a property similar to the one under consideration.

The study did not take into consideration other variables which are encountered in real stripping operations. It demonstrate only one approach in preliminary stripping analysis.

REFERENCES

1. H. Rumfelt: "Proper machinery mass for stripping overburden", Mining Engineering J.,May 1961, p. 480 - 487.

APPENDIX

(Pages A1 to A4)

```
      PROGRAM PMM
      implicit real(a-z)
      logical screen
      real smuf(1000),dmuf(1000),obdth(1000)
      integer n
      character prompt*1,fname*20,num*60
c length of x & y axis for graph
      xlen=9.95
      ylen=9.95
      write(*,*) ' PROGRAM PROPER MACHINERY MASS '
c get name of output file and open it
      write(*,*) ' Enter name of output file'
      read(*,'(a20)') fname
      open(unit=1,file=fname,status='new')
c find out if input is to be entered from screen or file
      write(*,*) ' Enter input parameters from screen(S) or file(F)?'
      read(*,'(a1)') prompt
      screen=.true.
      IIN=5
      if(prompt.eq.'F'.or.prompt.eq.'f') then
        IIN=2
        write(*,*) ' Enter the name of the input file'
        read(*,'(a20)') fname
        open(unit=IIN,file=fname,status='old')
        screen=.false.
      endif
c get input parameters from screen or file
      if(screen) write(*,*) ' Enter SWELL (pct) '
      read(IIN,*) swell
      if(screen) write(*,*) ' Enter Minimum Overburden Height (m) '
      read(IIN,*) xmin
      if(screen) write(*,*) ' Enter Maximum Overburden Height (m) '
      read(IIN,*) xmax
      if(screen) write(*,*) ' Enter Overburden increment (m)'
      read(IIN,*) xinc
      if(screen) write(*,*) ' Enter DEPOSIT THICKNESS (m)'
      read(IIN,*) t
      if(screen) write(*,*) ' Enter WIDTH of CUT (m) for Shovel'
      read(IIN,*) sw
      if(screen) write(*,*) ' Enter WIDTH of CUT (m) for Dragline'
      read(IIN,*) dw
      if(screen) write(*,*) ' Enter slope of repose'
      read(IIN,*) slope
      if(screen) write(*,*) ' Enter dipper factor'
      read(IIN,*) sfact
      if(screen) write(*,*) ' Enter cycle time for shovel (seconds)'
      read(IIN,*) scyct
      if(screen) write(*,*) ' Enter monthly hours of operation for shovel'
      read(IIN,*) smthhr
      if(screen) write(*,*) ' Enter expected operating factor for shovel'
      read(IIN,*) sopfct
      if(screen) write(*,*) ' Enter bucket factor'
      read(IIN,*) dfact
      if(screen) write(*,*) ' Enter cycle time for dragline (seconds)'
      read(IIN,*) dcyct
      if(screen) write(*,*) ' Enter monthly hours of operation for dragline'
      read(IIN,*) dmthhr
      if(screen) write(*,*) ' Enter expected operating factor for dragline'
      read(IIN,*) dopfct
      if(screen) write(*,410)
410   format(' Enter the height of the benchcut for dragline (m)')
      read(IIN,*) bcut
      if(screen) write(*,400)
400   format(' Enter required net Tons of cleaned coal per month ')
      read(IIN,*) qc
      if(screen) write(*,405)
```

```
405     format(' Enter yeild in net Tons of cleaned coal per Hectare')
        read(IIN,*) l
        write(*,*) ' Plot graph (Y/N)?'
        read(*,'(a1)') prompt
c write input parameters to output file
        write(1,500)
500     format('1      PROPER MACHINERY MASS OUTPUT')
        write(1,505)
505     format('0',3X,'INPUT PARAMETERS')
        write(1,510) swell,t
510     format('0   swell(%) = ',f6.2,' deposit thickness(m) =',f6.2)
        write(1,530) qc
530     format(4X,'Tons of clean coal required per month =  ',f10.2)
        write(1,540) l
540     format(4X,'Yeild in net Tons of cleaned coal/Hectare = ',f10.2)
        write(1,541) bcut
541     format(4X,'Height of benchcut for dragline (m) =',f10.2)
        write(1,525)
525     format('0',33x,'SHOVEL  DRAGLINE')
        write(1,520) sw,dw
520     format(4x,'Width of cut (m)',10x,2f10.2,1X)
        write(1,542) sfact,dfact
542     format(4x,'Dipper/Bucket factor',6x,2f10.2,1X)
        write(1,544) scyct,dcyct
544     format(4x,'Cycle time (seconds)',6x,2f10.2,1X)
        write(1,546) smthhr,dmthhr
546     format(4x,'Monthly operating hours',3x,2f10.2,1X)
        write(1,548) sopfct,dopfct
548     format(4x,'Monthly operating factor',2x,2f10.2,1X)
c calculate setimated monthly output
        sfct=estfac(sfact,scyct,smthhr,sopfct)
        dfct=estfac(dfact,dcyct,dmthhr,dopfct)
        write(1,549) sfct,dfct
549     format(4x,'Expected output/mth (cu.m)',f10.2,'D',f9.2,'B')
        write(1,550)
550     format('0',22x,'SHOVEL',30x,'DRAGLINE')
        write(1,560)
560     format('    ovbrdn',2(' height   reach  dipper     MUF   '))
        write(1,570)
570     format('    height',2(' of spoil          size            '))
        n=1
        ymin=999999.
        ymax=-999999.
        do 100 cuth=xmin,xmax,xinc
        call shovel(swell,cuth,t,sw,qc,l,slope,sfct,sh,sr,sd,smuf(n))
        call drag(swell,cuth,t,dw,qc,l,slope,dfct,bcut,dh,dr,dd,dmuf(n))
        obdth(n)=cuth
        write(1,600) obdth(n),sh,sr,sd,smuf(n),dh,dr,dd,dmuf(n)
600     format(4x,f5.1,2(1x,f8.1,1x,f7.2,1x,f7.2,1x,f9.1))
        if(smuf(n).gt.ymax) ymax=smuf(n)
        if(dmuf(n).gt.ymax) ymax=dmuf(n)
        if(smuf(n).lt.ymin) ymin=smuf(n)
        if(dmuf(n).lt.ymin) ymin=dmuf(n)
        n=n+1
100     continue
        if(prompt.eq.'Y'.or.prompt.eq.'y') then
          write(*,*) ' Position paper on plotter then press RETURN'
          read(*,'(a1)') prompt
          call scale1(xmax,xmin,xlen,xfirst,xfact)
          call scale1(ymax,ymin,ylen,yfirst,yfact)
          n=n-1
          smuf(n+1)=yfirst
          smuf(n+2)=yfact
          dmuf(n+1)=yfirst
          dmuf(n+2)=yfact
          obdth(n+1)=xfirst
```

```
          obdth(n+2)=xfact
c initalize plot
          call plots(0,0,6)
c move plot origin from edge of page
          call plot(3.5,6.,-3)
c draw axis
          call newpen(1)
          call axis(0.,0.,'OVERBURDEN DEPTH (m)',-20,xlen,0.,xfirst,xfact)
          call axis2(0.0,ylen,-xlen,0.0)
          call axis(0.,0.,'MUF NUMBERS (cu.m*m)',20,ylen,90.,yfirst,yfact)
          call axis2(xlen,0.0,ylen,90.)
c draw title
          xpage=23.
          ypage=10.
          xcen=(xpage-xlen)/2.+xlen
          csize=.4
          ypos=ypage-1.
          call symbol(xcen-(12.5*csize),ypos,.4,'MAXIMUM USEFULNESS FACTOR',
        3  14,0.0,25)
          ypos=ypos-csize*1.5
          call symbol(xcen-csize,ypos,csize,'VS',14,0.0,2)
          ypos=ypos-csize*1.5
          call symbol(xcen-(csize*8.),ypos,.4,'OVERBURDEN DEPTH',14,0.0,16)
c draw shovel and dragline lines
          call newpen(2)
          call line(obdth,smuf,n,1,1,0)
          call newpen(3)
          call line(obdth,dmuf,n,1,1,1)
          xpos=xlen+2.
c draw legend use pen colors that were used to draw lines
          call newpen(2)
          call symbol(xpos,ylen-2.5,.3,' ',0,0.0,-1)
          call symbol(xpos+.5,ylen-2.65,.3,'= SHOVEL',14,0.0,8)
          call newpen(3)
          call symbol(xpos,ylen-3.5,.3,' ',1,0.0,-1)
          call symbol(xpos+.5,ylen-3.65,.3,'= DRAGLINE',14,0.0,10)
c restore first pen
          call newpen(1)
c draw input parameters
          ypos=ylen-5.
          xpos=xpos-1.
          call symbol(xpos,ypos,.3,'INPUT PARAMETERS',14,0.0,16)
          ypos=ypos-.5
          csize=.25
          call symbol(xpos,ypos,csize,'Swell =',14,0.0,7)
          call number(xpos+8*csize,ypos,csize,swell,0.0,2)
          ypos=ypos-csize*1.5
          call symbol(xpos,ypos,csize,'Bed Thickness =',14,0.0,15)
          call number(xpos+16.*csize,ypos,csize,t,0.0,2)
          ypos=ypos-csize*1.5
          call symbol(xpos,ypos,csize,'Clean Tons/mth  =',14,0.0,17)
          call number(xpos+19.*csize,ypos,csize,qc,0.0,2)
          ypos=ypos-csize*1.5
          call symbol(xpos,ypos,csize,'Yield Tons/Hectare =',14,0.0,20)
          call number(xpos+22.*csize,ypos,csize,1,0.0,2)
          ypos=ypos-csize*1.5
          call symbol(xpos,ypos,csize,'Height of Benchcut for Dragline =',
        3             14,0.0,33)
          call number(xpos+34*csize,ypos,csize,bcut,0.0,2)
          ypos=ypos-csize*1.5
        write(num,525)
          call symbol(xpos,ypos,csize,num(5:52),14,0.0,47)
          ypos=ypos-csize*3
        write(num,520) sw,dw
          call symbol(xpos,ypos,csize,num(5:52),14,0.0,47)
          ypos=ypos-csize*1.5
```

```
        write(num,542) sfact,dfact
          call symbol(xpos,ypos,csize,num(5:52),14,0.0,47)
          ypos=ypos-csize*1.5
        write(num,544) scyct,dcyct
          call symbol(xpos,ypos,csize,num(5:52),14,0.0,47)
          ypos=ypos-csize*1.5
        write(num,546) smthhr,dmthhr
          call symbol(xpos,ypos,csize,num(5:52),14,0.0,47)
          ypos=ypos-csize*1.5
        write(num,548) sopfct,dopfct
          call symbol(xpos,ypos,csize,num(5:52),14,0.0,47)
          ypos=ypos-csize*1.5
        write(num,549) sfct,dfct
          call symbol(xpos,ypos,csize,num(5:52),14,0.0,47)
c terminate plot
          call plot(0.,0.,999)
        endif
        close(unit=1)
        stop
        end

c ********************************

        function estfac(fact,cyctim,ophr,mthfact)
        implicit real(a-z)
        estfac=aint(3600./cyctim)*fact*ophr*mthfact
        return
        end

        subroutine shovel(swell,cuth,t,w,qc,l,slope,fact,h,r,d,muf)
c subroutine that calculates maximum usefulness factor, reach, h,d for shovel
        implicit real (a-z)
        h=(1.+(swell/100.))*cuth-t+w/5.
        r=slope*h
        d=qc*10000.*cuth/(l*fact)
        muf=r*d
        return
        end

c ********************************

        subroutine drag(swell,cuth,t,w,qc,l,slope,fact,bcut,h,r,d,muf)
c subroutine that calculates maximum usefulness factor, reach, h,d for dragline
        implicit real (a-z)
        h=(1.+(swell/100.))*cuth-t+w/5.
        r=(.33*cuth-(.33*bcut))+slope*h
        d=qc*10000.*cuth/(l*fact)
        muf=(.33*cuth-(.33*bcut))+slope*h*d
        return
        end
```